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(54) **EVALUATION AND COACHING OF ATHLETIC PERFORMANCE**

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A63B 24/00 (2006.01)
(Continued)

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CPC ***A63B 24/0062*** (2013.01); ***A61B 5/1123*** (2013.01); ***A61B 5/1128*** (2013.01);
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CPC G09B 19/003; G09B 19/0038; A63B 24/0062; A63B 24/0075; A63B 24/065; A63B 24/0068
See application file for complete search history.

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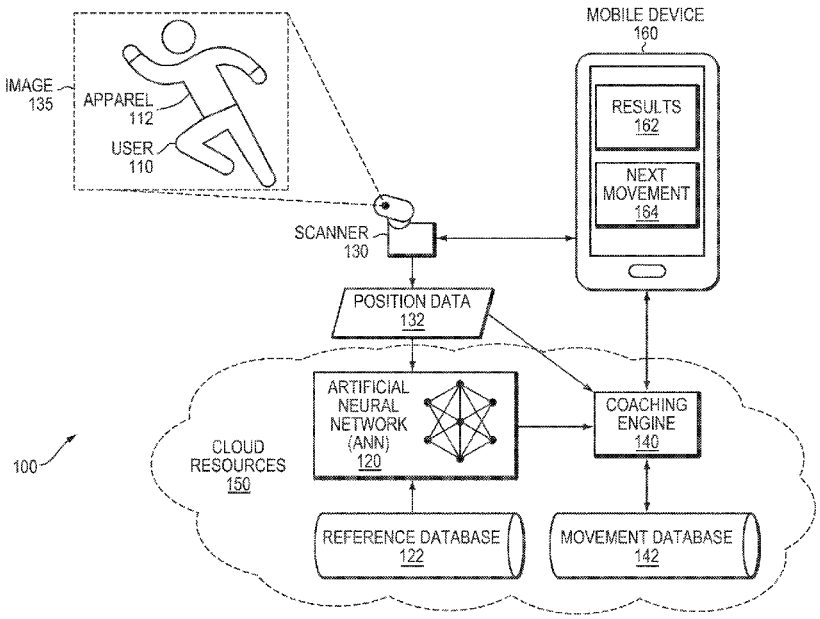
(57) **ABSTRACT**

An automated system provides for tracking and evaluation performance of an athlete. An athlete is tracked during performance of a movement, and position data of the performance is applied to an artificial neural network (ANN) trained via a reference data set representing recorded movements. Using the ANN, rank data for the performance is be determined, where the rank data indicates a relationship between the performance of the movement and a subset of the plurality of recorded movements. Based on the rank data, the athlete can be presented with an evaluation of the performance, instructions for subsequent movements and suggestions for improving the athlete's performance.

24 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

G06K 9/00	(2006.01)
A61B 5/11	(2006.01)
A61B 5/00	(2006.01)
A63B 71/06	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 5/7267*** (2013.01); ***A63B 24/0006*** (2013.01); ***A63B 71/0622*** (2013.01); ***G06K 9/00342*** (2013.01); ***G09B 19/003*** (2013.01); *A61B 5/1118* (2013.01); *A61B 2503/10* (2013.01); *A63B 2220/12* (2013.01); *A63B 2220/40* (2013.01); *A63B 2220/836* (2013.01); *A63B 2225/50* (2013.01); *A63B 2230/04* (2013.01)

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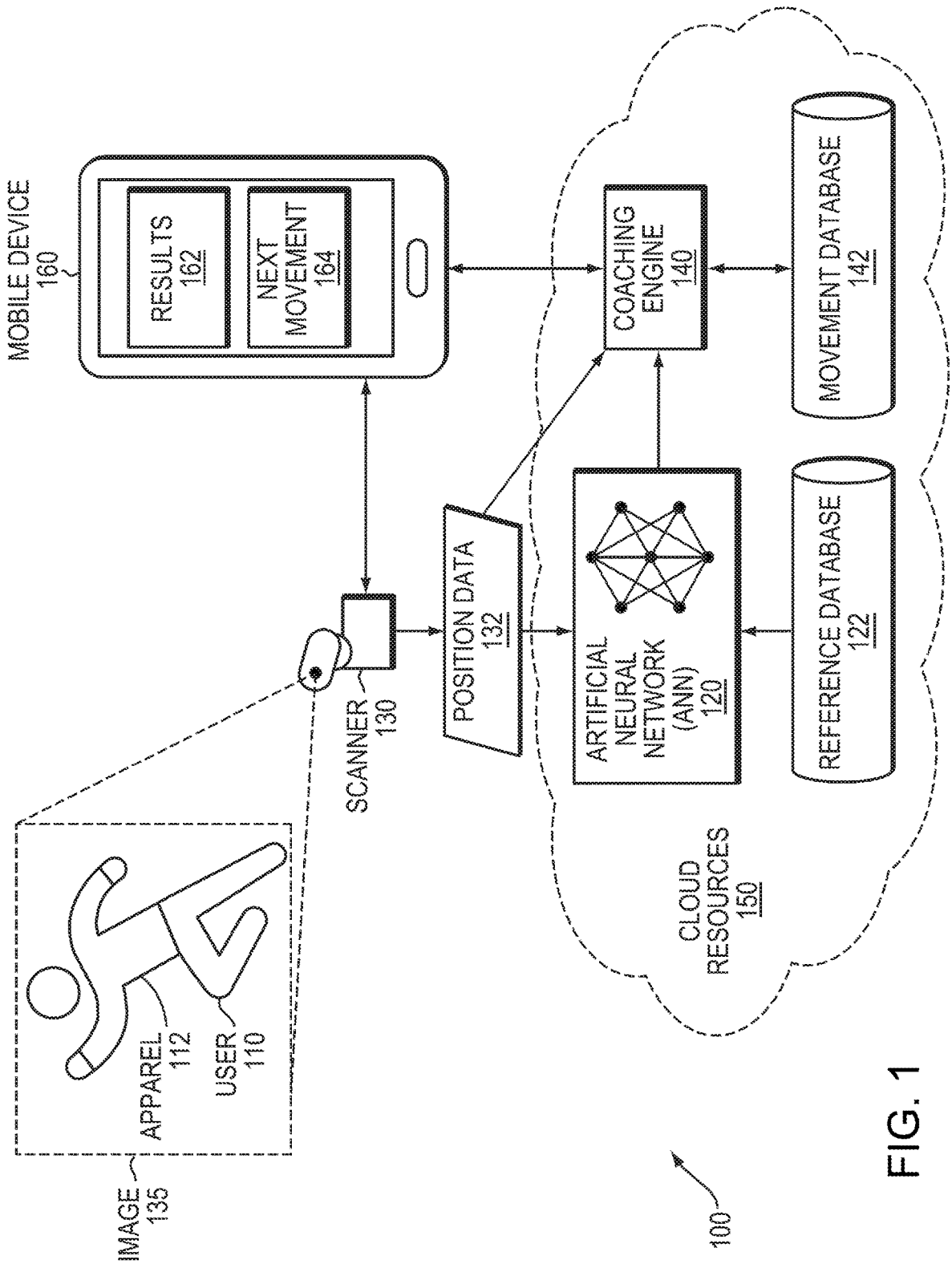
MOBILE DEVICE
160
RESULTS
162
NEXT
MOVEMENT
164
COACHING
ENGINE
140
MOVEMENT DATABASE
142
SCANNER
130
POSITION DATA
132
ARTIFICIAL
NEURAL
NETWORK
(ANN)
120
REFERENCE DATABASE
122
CLOUD
RESOURCES
150
APPAREL
112
USER
110
IMAGE
135
100

FIG. 1

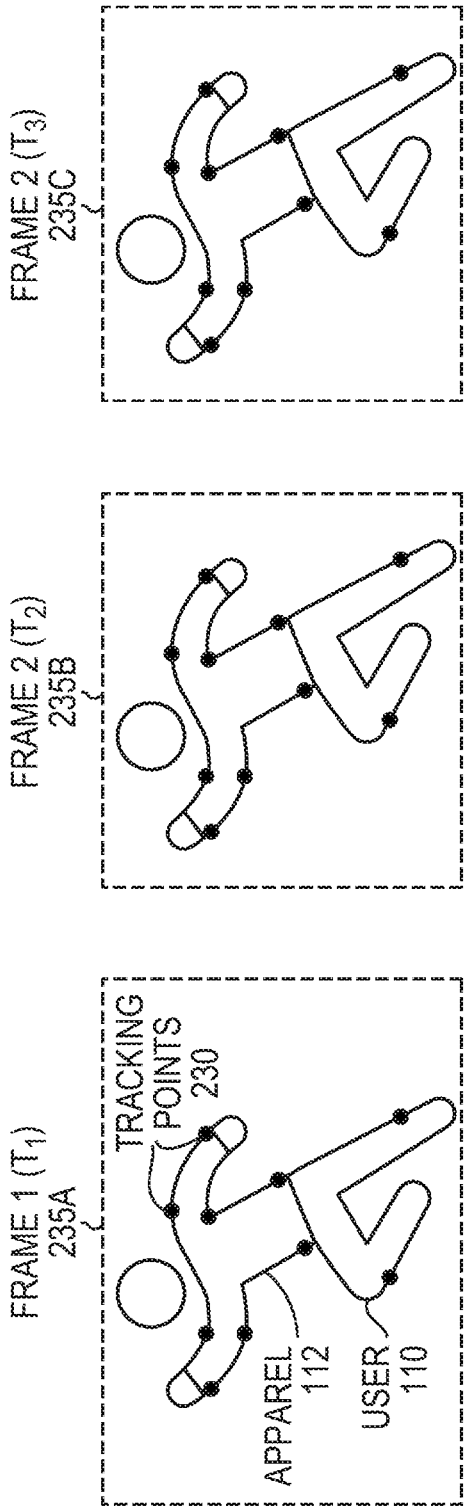
FRAME 1 (T_1)
235A
TRACKING POINTS
230
APPAREL
112
USER
110
FRAME 2 (T_2)
235B
FRAME 2 (T_3)
235C

FIG. 2A

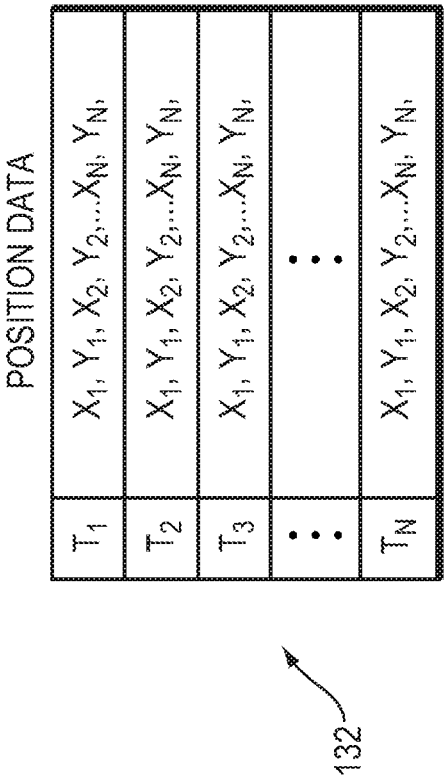
POSITION DATA
T_1
$X_1, Y_1, X_2, Y_2, ...X_N, Y_N,$
T_2
$X_1, Y_1, X_2, Y_2, ...X_N, Y_N,$
T_3
$X_1, Y_1, X_2, Y_2, ...X_N, Y_N,$
T_N
$X_1, Y_1, X_2, Y_2, ...X_N, Y_N,$
132

FIG. 2B

REFERENCE DATA SET

MOVEMENT ID	MOVEMENT DATA	RANK DATA
MOVEMENT 1	M_1	[0,2,4]
MOVEMENT 2	M_2	[3,7,1]
MOVEMENT 3	M_3	[0,7,2]
⋮	⋮	⋮
MOVEMENT N	M_N	[2,2,5]

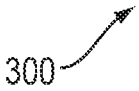

FIG. 3

COACHING TABLE

RANK	COACHING INSTRUCTIONS
1	C_1
2	C_3, C_2
3	C_2, C_4
⋮	⋮
N	C_6, C_4

401

MOVEMENT TABLE

RANK	MOVEMENTS
1	W_1, W_4, W_7
2	W_7, W_3, W_2
3	W_7, W_9, W_{12}
⋮	⋮
N	W_5, W_8, W_{17}

402

FIG. 4

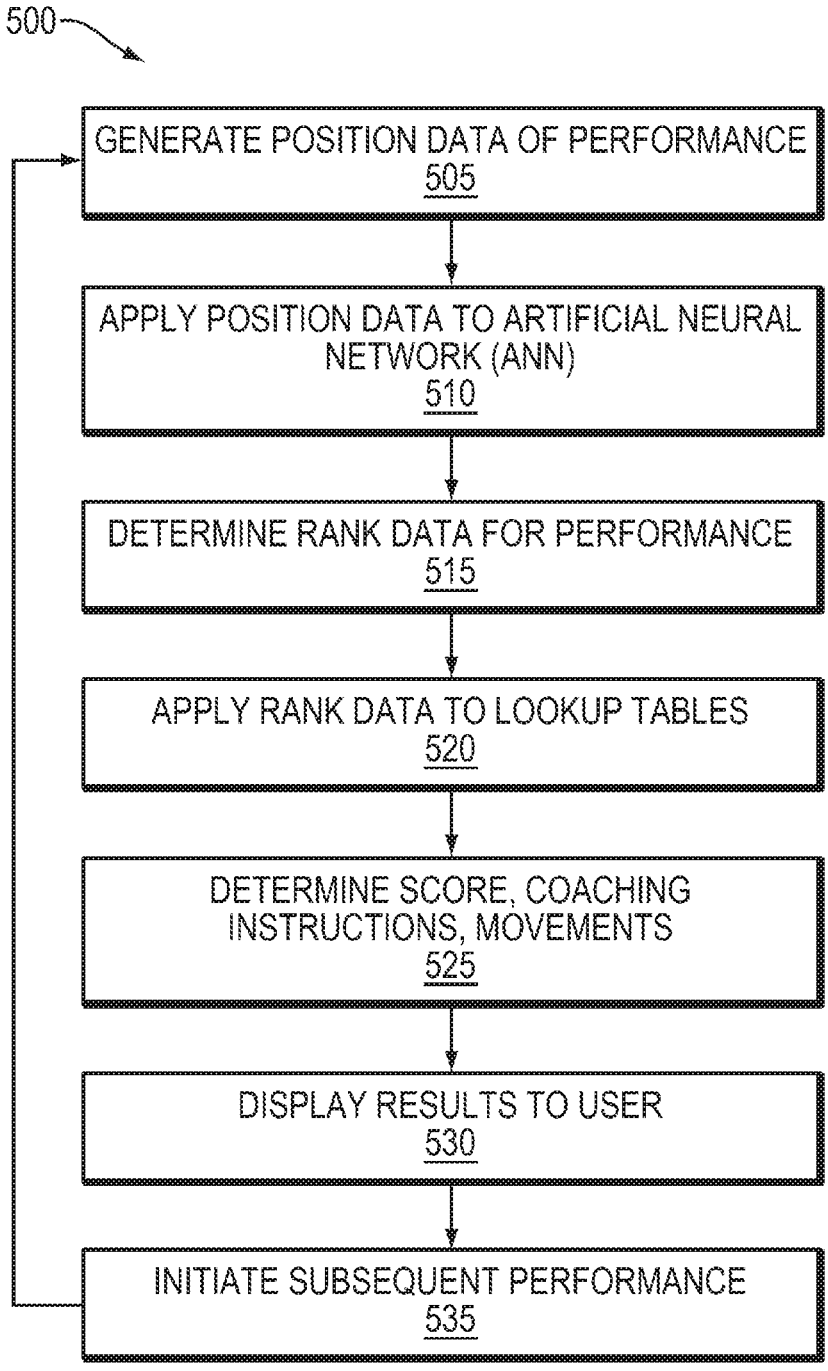
500
GENERATE POSITION DATA OF PERFORMANCE
505
APPLY POSITION DATA TO ARTIFICIAL NEURAL NETWORK (ANN)
510
DETERMINE RANK DATA FOR PERFORMANCE
515
APPLY RANK DATA TO LOOKUP TABLES
520
DETERMINE SCORE, COACHING INSTRUCTIONS, MOVEMENTS
525
DISPLAY RESULTS TO USER
530
INITIATE SUBSEQUENT PERFORMANCE
535

FIG. 5

	DAY 3			
	Week 1	Week 2	Week 3	Week 4
SMR				
AIS				
NMA				
MS				

Day 1	Back Squat							
	x5		x5		x5		x5	
	x5		x5		x5		x5	
	x5		x5		x5		x5	
	x5		x5		x5		x5	
	x5		x5		x5		x5	
	Goblet Lateral Lunge							
	super set							
	Sissy Squat 4x50							
	x8		x8		x8		x8	
	x8		x8		x8		x8	
	x8		x8		x8		x8	
	x8		x8		x8		x8	

Day 2	Leg Press 15, 10, 10 Drops							
	SL Extensions 15, 10, 10 Drops							
	x15		x15		x15		x15	
	x15		x15		x15		x15	
	x15		x15		x15		x15	
	DROP		DROP		DROP		DROP	
	Goblet Squat 15, 10, 10 Drops							
	Extensions 15, 10, 10 Drops							
	x15		x15		x15		x15	
	x15		x15		x15		x15	
	x15		x15		x15		x15	
	FAIL		FAIL		FAIL		FAIL	

Day 3	30s ON 15s OFF 3 Rounds							
	Matrix Parachute Run							
	Atlas Ball Over Shoulder Chains							
	Hollow Rocking							

FIG. 6

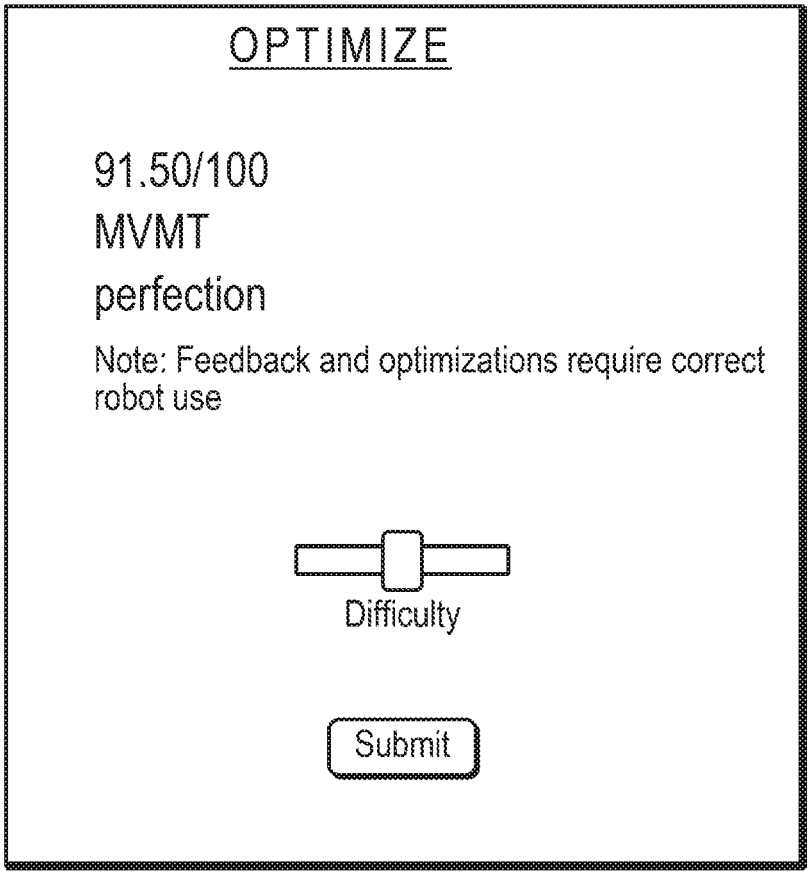
OPTIMIZE
91.50/100
MVMT
perfection
Note: Feedback and optimizations require correct robot use
Difficulty
Submit

FIG. 7

EVALUATION AND COACHING OF ATHLETIC PERFORMANCE

RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 62/513,123, filed on May 31, 2017; and U.S. Provisional Application No. 62/400,928, filed on Sep. 28, 2016. The entire teachings of the above applications are incorporated herein by reference.

BACKGROUND

Coaching an individual for an athletic pursuit, or other goals relating to fitness, is a subjective practice that typically requires in-person consultation. A coach will observe an athlete's performance and, drawing on experience and expertise, advise the athlete on how to improve his or her performance. The coach might offer suggestions for improving the movements observed by the coach, recommendations for an exercise routine, and advice on diet and nutrition. By harnessing the expertise of a coach, an athlete can make great strides in his or her performance.

SUMMARY

Example embodiments include a method of training an athlete. Position data is generated based on image data of an athlete during performance of a first movement, where the position data indicates position of the athlete over time during the performance of the first movement. The position data may then be applied to an artificial neural network (ANN) trained via a reference data set representing a plurality of recorded movements of a movement category common to the first movement. The reference data set can include position data and a reference rank value for each of the plurality of recorded movements. Using the ANN, a rank value for the performance of the first movement can be determined, where the rank value indicates a relationship between the performance of the first movement and a subset of the plurality of recorded movements. Based on the rank value, instructions for a second movement can be determined, and the athlete can be notified of the instructions. It should be understood that an ANN is an example of a processing technique and that other forms of processing can be employed to perform the operations disclosed herein.

In further embodiments, the second movement may belong in a movement category common to the first movement, and the instructions for the second movement advise the athlete to perform the second movement differently from the performance of the first movement. Further, a performance of the second movement can be captured and processed in a manner comparable to the first movement, providing the athlete with further instructions.

In still further embodiments, the athlete may be notified of a distinction between the performance of the first movement and at least one of the recorded movements. At least one of the recorded movements may have a respective rank value greater than the rank value of the performance of the first movement. The instructions for the second movement may include instructions for traversing the distinction.

In yet further embodiments, the second movement may be of a movement category distinct from the movement category of the first movement. The second movement may include a plurality of subset movements, the instructions specifying 1) a number of repetitions of the subset movements, 2) a time over which to perform the subset movements, and/or 3) a distance over which to perform the subset movements. The instructions may also be based on an input by the athlete identifying a prospective improvement in the performance of the first movement.

Further embodiments may include determining a measure of fatigue of the athlete during the performance of the first movement based on the position data, and instructions for the second movement may be based on the measure of fatigue. Based on the measure of fatigue, an estimation of muscle fiber type for the athlete may be determined. Further, a group of movements may be determined based on the rank value, where the instructions are determined based on the athlete's selection among the group of movements. The reference rank value may be based on a manual assessment of the respective recorded movement. The image data of the athlete may be captured during performance of the first movement. A camera used for capturing the image data of the athlete may be calibrated, where the calibrating includes identifying a color of apparel worn by the athlete.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing will be apparent from the following more particular description of example embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating embodiments of the present invention.

FIG. **1** is a diagram of a coaching system in one embodiment.

FIG. **2**A is a diagram illustrating capture of an athlete's movements.

FIG. **2**B is a table of position data representing an athlete's movements.

FIG. **3** is a table of a reference data set including movement data.

FIG. **4** illustrates tables of instructions to a user.

FIG. **5** is a flow diagram of a method of training an athlete in one embodiment.

FIG. **6** is a screenshot of a display including workout information.

FIG. **7** is a screenshot of a display including results of analyzing an athlete's movement.

DETAILED DESCRIPTION OF THE INVENTION

A description of example embodiments of the invention follows.

FIG. **1** is a diagram of a coaching system **100** in one embodiment. The system **100** may include a scanner **130** and cloud resources **150**. A user **110** (also referred to as an athlete) may interface with the system **100** though a mobile device **160** (e.g., a smartphone or tablet, enlarged for clarity), which may be wirelessly communicatively coupled to the scanner **130** and/or the cloud resources **150** via a WiFi, Bluetooth or other communications protocol. The system **100** provides the user **110** with an evaluation of the user's performance of a movement (e.g., a given exercise, workout or fitness test), as well as coaching to improve the user's performance and other aspects of health and fitness.

Prior to a coaching session with the system **100**, the user **110** may set up the scanner **130** within a training environment. Specifically, the camera of the scanner **130** may be pointed towards the user **110** so as to capture images of the user **110** during performance of a movement. For example,

if the movement to be evaluated is a box jump, the scanner **130** may be configured so that the full range of the user's movement, including the beginning and end of the box jump, are captured within the frame of each image. The scanner **130** may also be calibrated by registering the color or appearance of the user's apparel **112**, thereby improving recognition of the user's movements. The user **110** may facilitate this calibration by interacting with the mobile device **160** to complete a calibration process **160**. The scanner **130** may include the camera as well as image processing circuitry and a wired or wireless network interface to transmit captured image data. A single-board computer (SBC), such as a Raspberry Pi™ computer, may be implemented in the scanner **130** to provide such processing and interface functions. In alternative embodiments, the mobile device **160** may be implemented in place of, or supplemental to, the scanner **130**, where a camera integral to the mobile device **160** captures images of the user's performance.

To initiate a coaching session with the system **100**, the user **110** may interact with the mobile device **160**. Here, the user **110** may select from a range of different movements to be evaluated, which can be presented as various examinations for physical fitness, muscle fiber type, or a specific movement. Upon selection of a test, the user **110** follows instructions presented on the mobile device **160** to perform the movement. During the performance, the scanner **130** captures images (e.g., image **135**) of the user **110** and generates position data **132** representing the user's position in each image. Alternatively, the scanner **130** may simply capture the image data without further processing, instead forwarding the image data to the cloud resources **150** or mobile device **160** to generate the position data **132**. A process of image capture and generating the position data **132** is described in further detail below with reference to FIGS. **2**A-B.

The cloud resources **150** may include an artificial neural network (ANN) **120**, a coaching engine **140**, a reference database **122**, and a movement database **142**. The ANN **120** may be emulated by suitable computing resources, such as a computer server including one or more graphics processing units (GPUs), and may be trained by reference data at the reference database **122**. Reference data may include data regarding previously performed movements, as well as evaluation data for those movements. An example reference data set is described in further detail below with reference to FIG. **3**. The ANN **120** may include a plurality of distinct sub-ANNs, where each ANN is trained with data of a particular movement category (e.g., box jumps). The position data **132** may be applied to the ANN **120**, and, in particular, to the sub-ANN that is trained for the movement category matching the movement performed by the user **110**. The ANN **120** processes the position data **132** to determine similarities between the performed movement and the movements represented in the reference data. Based on the determined similarities, the ANN **120** outputs rank data, which identifies such similarities, to the coaching engine **140**. For example, the rank data can indicate or include 1) which one or more of the movements represented by the reference data is most similar to the performed movement; 2) a class or subset of the reference movements that is a best match for the performed movement, where each class may correspond to a given characteristic, performance level, or flaw in the movement; or 3) a numerical (e.g., X out of 100) or graded ranking of the performed movement derived from a subjective (e.g., coach-observed) evaluation of the reference movements most similar to the performed movement.

The coaching engine **140** implements the rank data, data about the user (e.g., gender, weight, age, goals, and physical abilities measured in previous coaching sessions), and, optionally, the position data **132**, to determine coaching information for the user **110**. To do so, the coaching engine **140** may reference the movement database **142**. The movement database **142** may store one or more lookup tables cross-referencing rank data and/or position data with coaching information. The coaching information can include coaching instructions (e.g., correction to form of a movement), descriptions of movements (e.g., workout routines), evaluation of the performance (e.g., a "grade" ranking the performance) and/or other suggestions to inform the user **110**. Example coaching information is described below with reference to FIG. **4**. As a result of referencing the movement database **142**, the coaching engine **140** can determine appropriate coaching information for the user **110** and present the information via the mobile device **160**. For example, the mobile device **160** may display results **162** of the performance (e.g., time, ranking, grade) and instructions for a next movement **164** (e.g., instructions to correct a deficiency in the performance, a workout routine). The coaching engine **140** may also store the results of the performance, such as rank data and position data **132**, to the movement database **142**, and may reference those results when evaluating subsequent performances by the user **110**.

FIG. **2**A is a diagram illustrating detection of the user's position during performance of the movement. Frames **235**A-C represent successive images during the performance as captured, for example, by the scanner **130** described above with reference to FIG. **1**. The frames **235**A-C depict the user **110** moving position relative to the camera's field of view (FOV). In order to track the user's movements, the scanner **130** may identify a plurality of tracking points **230**. The tracking points **230** may be designated first during a calibration process as described above, and can be maintained during the user's motion as a result of cross-referencing the user's image between successive images. The scanner **130** may reference the user's apparel **112** to assist in maintaining the tracking points **230**, and may identify the apparel **112** by contrast (e.g., color or pattern difference) against other object in the image. For example, the scanner **130** may maintain the tracking points at relative points along a silhouette of the apparel **112** and other portions of the user **110**.

FIG. **2**B is a table of the position data **132** representing the user's movements. The first column identifies the time stamp for a given frame (shown as $T_1 \ldots T_N$), and the second column includes coordinates of each of the tracking points **230** in the given frame. For example, the column may include numerical, X-Y coordinates for each of the tracking points **230** (e.g., $X_1, Y_1, X_2, Y_2 \ldots X_N, Y_N$) as they are delineated in the 2D plane of the frame. The X-Y coordinates may be captured as the pixel coordinates of the given frame, and may be entered into the ANN **120** or may first be translated to physical coordinates (e.g., via the use of an object of known size to provide a scale, or via an estimate based on the recorded velocity of the movement). Alternatively, if the scanner **130** (alone or in combination with another device, such as the mobile device **160**) captures stereoscopic or other 3D image data of the user **110**, then the position data **132** may include 3D coordinates of the tracking points **230**. 3D image data, in particular, can aid in determining the physical coordinates of the tracking points **230** through the movement.

FIG. **3** is a table of a reference data set **300**. The reference data set **300** may be stored in the reference database **122** of

FIG. **1**, and may be employed to train the ANN **120**. The reference data set **300** may be specific to a particular movement category, wherein all of the entries represent movements of a common type (e.g., a box jump). For example, each entry may represent a previously recorded demonstration of the movement, which may have been captured by a process comparable to that described above with reference to the system **100**. In order to provide coaching and evaluation for a range of different movements, the reference database **122** may include a plurality of different reference data sets, each data set pertaining to a different movement category. Each reference data set can be implemented to train a respective ANN.

The reference data set **300** includes a first column including a "movement identifier" (ID) for each of the represented movements. A second column stores movement data, which includes information about the movement. The movement data can include, for example, data comparable to the position data **132** shown in FIG. **2**B, including a succession of tracking point coordinates and respective timestamps. In order to optimize the training of the ANN **120**, the movement data may be recorded by means comparable to that by which the position data **132** is recorded (e.g., via the scanner **130** or a comparable device, and the recorded athlete following instructions comparable to those presented to the user **110** prior to the performance). As a result, the ANN **120** may be sufficiently adapted to identify parallels between the position data **132** and the reference data set **300**.

A third column of the reference data set **300** stores rank data. The rank data for each movement may include numerals or other code identifying objective and/or subjective information about the movement. For example, a first numeral may identify a "grade," or subjective evaluation, or the movement as determined by a human coach observing the movement. This evaluation may also correspond to a ranking (e.g., a percentile value) of the movement relative to other movements. A second numeral may identify one or more flaws in the movement, such as a deficiency in technique, as determined by the coach. A third numeral may identify objective information about the movement, such as the identity of the athlete performing the movement, or the total time in which the movement was completed. A fourth numeral may identify information about the athlete performing the movement, such as the athlete's muscle fiber type.

The ANN **120**, being trained with the reference data set **300**, processes the user's position data **132** to identify parallels between the position data **132** and the reference data set **300**. As a result, the ANN **120** determines appropriate rank data for the position data **132**. This data, referred to as user rank data, is output by the ANN **120** to the coaching engine **140**. The coaching engine **140**, in turn, applies the user rank data to one or more lookup tables to determine appropriate evaluation and coaching information corresponding to the user's performance. Example lookup tables are described in further detail with reference to FIG. **4** below.

FIG. **4** illustrates lookup tables **401**, **402** for cross-referencing rank data and coaching information. With reference to FIGS. **1** and **3**, the coaching engine **140** may apply the user rank data to the tables **401**, **402**. The coaching table **401** correlates a rank value with coaching instructions (C_1-C_N), which represent instructions that may be provided to a user **110** to improve the users performance. For example, instruction C_1 may correspond to suggestions for modifying the user's form when performing the movement, and instruction C_2 may correspond to a suggestion for a pre-performance action (e.g., a stretch or mobility work) to improve the user's range of motion. To optimize data storage, the table **401** may store pointers to instructions rather than the instructions themselves, where C_1-C_N point to the instructions located in another table (not shown) stored in the movement database **142** or another database.

The movement table **402** correlates a rank value (which may be distinct from the rank values applied to the coaching table **401**) with movements (W_1-W_N), which represent a range of suggestions that may be presented to the user **110**. For example, W_1 may correspond to a variation of the movement performed by the user **110**, W_2 may correspond to a structured interval training routing, W_3 may correspond to a structured strength training routine, W_4 may correspond to a mobility routine, W_5 may correspond to an endurance training routine (e.g., swimming, distance running), and W_6 may correspond to a diet recommendation. Similarly to the table **401**, the table **402** may store pointers to the above movements as located in another table (not shown).

Upon applying the user rank values to the tables **401**, **402**, the coaching engine **140** may compile the corresponding coaching instructions and movements and present them to the user **110** via the mobile device **160**, and may be included in the results **162** and next movement **164**. If the coaching engine **140** presents a suggested movement that can be tracked by the system **100**, and the user **110** selects that movement, then the system **100** may carry out a subsequent process of tracking and evaluating the user's performance of the suggested movement. The coaching engine **140** can also present the user rank data directly (e.g., a rank value that indicates a grade or percentile of the performance), can present objective measurements of the performance based on the position data **132** (e.g., time completed, velocity, acceleration), or can apply the user rank data to other lookup tables or data sources to present other information to the user **110**. For example, the user rank data and/or position data **132** may be compared against data regarding previous performances by the user **110** to determine whether how the user's performance has changed or improved. Similarly, the user rank data and/or position data **132** may be compared against data regarding performances by other athletes, informing the user **110** how his/her performance compares to those performances.

In a further embodiment, the coaching engine **140** may estimate the muscle fiber composition of the user **110** based on the position data **132** and/or user rank data. The user rank data may include such an estimate directly (e.g., as a result of the ANN **120** being trained with known muscle fiber types included in the reference data set **300**), or may be calculated based on the position data **132**.

FIG. **5** is a flow diagram of an example process **500** of training an athlete in one embodiment. The process **500** may be implemented by the system **100** of FIG. **1**, and may incorporate one or more of the features described above with reference to FIGS. **1**-**4**. Upon initiating a coaching session, the scanner **130** captures images of the user's performance in completing a movement, and generates corresponding position data **132** (**505**). The position data **132** is uploaded to the cloud resources **150**, where it is applied to the ANN **120** trained on a reference data set **300** of a common movement category (**510**). Through the ANN **120**, the user rank data for the performance is determined (**515**). The coaching engine **140** then applies the user rank data to lookup tables **401**, **402** (**520**), and determines a performance score, coaching instructions and suggestions for movements (e.g., structured workout routines) (**525**). The results are then presented to the user **110** at the mobile device **160** (e.g., results **162** and next movement **164**) (**530**). If the user **110**

selects the next movement **164** for evaluation, then a subsequent performance is initiated (**535**), and the process **500** is repeated to evaluate the subsequent performance.

Further embodiments may be configured to provide coaching in physical therapy applications. In such an application, as well as in other training applications, the process **500** may be initiated after a user **110** selects a movement (e.g., a rehabilitation movement) to perform from a menu of movements presented at a user interface (e.g., mobile device **160**). The operations of analyzing the recorded movement (**510**-**525**) may be configured to identify and coach specific flaws in the movement related to given injuries from which the user **110** may be recovering. Accordingly, the results displayed to the user **110** (**530**) may include particular guidance for improving the movement, such as range of motion, velocity, subjective quality of movement based on comparable reference movements, and coaching suggestions for movements and exercises to improve the user's performance.

FIG. **6** is a screenshot of a display including workout information. The workout information may include a structured workout routine, including a listing of movements to be performed, as well as a calendar organizing the timing of the routine. The workout information may be configured by the coaching engine **140**, and may be based on suggested movements retrieved from the lookup table **402**. The display may also include spaces where the user **110** can manually enter results of the workout (e.g., weight lifted, time completed).

FIG. **7** is a screenshot of a display including results of evaluating an athlete's performance. The display includes a score ("91.50/100") for the performance of a movement, which may be derived from the user rank data, the position data **132**, and/or a lookup table (e.g., tables **401**, **402**). The display also includes a difficulty slider, enabling the user **110** to select a relative difficulty for the next movement to perform. In response to this selection, the coaching engine **140** may modify established movements from the movement database **142** to create a movement having higher or lower difficulty.

Example embodiments may include a computer program product, including a non-transitory computer-readable medium (e.g., a removable storage medium such as one or more DVD-ROM's, CD-ROM's, diskettes, tapes, etc.) that provides at least a portion of the software instructions for the invention system. The computer program product can be installed by any suitable software installation procedure, as is well known in the art. In another embodiment, at least a portion of the software instructions may also be downloaded over a cable communication and/or wireless connection.

While this invention has been particularly shown and described with references to example embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

What is claimed is:

1. A computer-implemented method of training an athlete, comprising:

generating position data based on image data of an athlete during a first performance of a movement, the position data including pixel coordinates of a plurality of tracking points associated with the athlete for multiple frames of the image data, the position data indicating position of the athlete over time during the first performance of the movement;

applying the position data to an artificial neural network (ANN) trained via a reference data set representing a plurality of recorded performances of the movement, the reference data set including position data and a reference rank value for each of the plurality of recorded performances;

identifying, via the ANN, a correlation between the position data and at least one of the recorded performances of the movement;

determining, via the ANN, a rank value for the performance of the first movement based on the correlation, the rank value indicating a relationship between the first performance of the movement and a subset of the plurality of recorded performances;

applying the rank value to a table to identify coaching instructions corresponding to the rank value, the table cross-referencing a plurality of rank values and coaching instructions corresponding to each of the plurality of rank values;

determining instructions for a second performance of the movement by selecting from the coaching instructions corresponding to the rank value, the second performance corresponding to the first performance with the exception of a correction to form of the first performance, the instructions for the second performance including instructions to perform the second performance in a manner distinct from the first performance; and

notifying the athlete of the instructions for the second performance of the movement.

2. The method of claim **1**, further comprising:

capturing image data of an athlete during the second performance of the movement;

determining, via the ANN, a rank value for the second performance of the movement, the rank value indicating a relationship between the second performance of the movement and a subset of the plurality of recorded performances;

comparing the rank values of the first and second performances; and

notifying the athlete based on the comparison.

3. The method of claim **1**, further comprising notifying the user of a distinction between the first performance and at least one of the recorded performances.

4. The method of claim **3**, wherein the at least one of the recorded performances has a respective rank value greater than the rank value of the first performance.

5. The method of claim **3**, wherein the instructions for the second performance include instructions for traversing the distinction.

6. The method of claim **1**, further comprising determining instructions for a further movement based on the rank value, the further movement being of a movement category distinct from the movement category of the movement.

7. The method of claim **1**, wherein the second performance includes a plurality of subset movements, the instructions specifying at least one of 1) a number of repetitions of the subset movements, 2) a time over which to perform the subset movements, and 3) a distance over which to perform the subset movements.

8. The method of claim **1**, wherein determining the instructions for the second performance is further based on an input by the athlete identifying a prospective improvement in the first performance.

9. The method of claim **1**, further comprising determining a measure of fatigue of the athlete during the first performance based on the position data.

10. The method of claim 9, wherein determining instructions for the second performance is based on the measure of fatigue.

11. The method of claim 9, further comprising determining an estimation of muscle fiber type for the athlete based on the measure of fatigue.

12. The method of claim 1, further comprising determining a group of movements based on the rank value, and further comprising determining a further movement based on a selection, by the athlete, of the further movement from among the group of movements.

13. The method of claim 1, wherein the reference rank value is based on a manual assessment of the respective recorded performance.

14. The method of claim 1, further comprising capturing the image data of the athlete during the first performance.

15. The method of claim 14, further comprising calibrating a camera used for capturing the image data of the athlete, the calibrating including identifying a color of apparel worn by the athlete.

16. A computer-implemented method of training an athlete, comprising:

generating position data based on image data of an athlete during performance of a first movement, the position data including pixel coordinates of a plurality of tracking points associated with the athlete for multiple frames of the image data, the position data indicating position of the athlete over time during the first performance of the first movement;

applying the position data to an artificial neural network (ANN) trained via a reference data set representing a plurality of recorded performances of the movement, the reference data set including position data and a reference rank value for each of the plurality of recorded performances;

identifying, via the ANN, a correlation between the position data and at least one of the recorded performances of the movement;

determining, via the ANN, a rank value for the performance of the first movement based on the correlation, the rank value indicating a relationship between the performance of the first movement and a subset of the plurality of recorded performances;

applying the rank value to a table to identify coaching instructions corresponding to the rank value, the table cross-referencing a plurality of rank values and coaching instructions corresponding to each of the plurality of rank values;

determining a group of distinct movements by selecting from the coaching instructions corresponding to the rank value;

determining instructions for a second movement based on a selection, by the athlete, among the group of distinct movements; and

notifying the athlete of the instructions for the second movement.

17. The method of claim 16, wherein the second movement is of a movement category distinct from the movement category of the first movement.

18. The method of claim 16, wherein the second movement includes a plurality of subset movements, the instructions specifying at least one of 1) a number of repetitions of the subset movements, 2) a time over which to perform the subset movements, and 3) a distance over which to perform the subset movements.

19. The method of claim 16, wherein the reference rank value is based on a manual assessment of the respective recorded performance.

20. The method of claim 16, further comprising determining a measure of fatigue of the athlete during the performance of the first movement based on the position data.

21. A system for training an athlete, comprising:

an artificial neural network (ANN) trained via a reference data set representing a plurality of recorded performances of the movement, the reference data set including position data and a reference rank value for each of the plurality of recorded performances;

a server configured to communicate with a scanner and a computing device across a network, the server configured to:

generate position data based on image data captured by the scanner of an athlete during a first performance of a movement, the position data including pixel coordinates of a plurality of tracking points associated with the athlete for multiple frames of the image data, the position data indicating position of the athlete over time during the first performance of the movement;

apply the position data to the ANN;

identify, via the ANN, a correlation between the position data and at least one of the recorded performances of the movement

determine, via the ANN, a rank value for the performance of the first movement based on the correlation, the rank value indicating a relationship between the first performance of the movement and a subset of the plurality of recorded performances;

applying the rank value to a table to identify coaching instructions corresponding to the rank value, the table cross-referencing a plurality of rank values and coaching instructions corresponding to each of the plurality of rank values;

determine instructions for a second performance of the movement selecting from the coaching instructions corresponding to the rank value, the second performance corresponding to the first performance with the exception of a correction to form of the first performance, the instructions for the second performance including instructions to perform the second performance in a manner distinct from the first performance; and

transmit the instructions for the second performance of the movement to the computing device.

22. The system of claim 21, wherein the server is further configured to transmit to the computing device a notification of a distinction between the performance of the first movement and at least one of the recorded performances.

23. The system of claim 22, wherein the at least one of the recorded performances has a respective rank value greater than the rank value of the first performance of the movement.

24. The system of claim 22, wherein the instructions for the second performance include instructions for traversing the distinction.

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